PB-251 777

BADIN LAKE, MONTGOMERY AND STANLEY COUNTIES, NORTH CAROLINA

Pacific Northwest Environmental
Research Laboratory

Prepared for:

National Environmental Research Center

June 1975

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TECHNICAL REPORT DATA
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1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Report on Badin Lake, Montgomery and Stanly Counties, North Carolina.		5. REPORT DATE Prepared June, 1975 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper #377
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1973 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

18. DISTRIBUTION STATEMENT Release unlimited	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES 42pp.
	20. SECURITY CLASS *(This page)*	22. PRICE 4.00

EPA Form 2220-1 (9-73)

PB 251 777

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

NATIONAL ENVIRONMENTAL RESEARCH CENTER - CORVALLIS, OREGON

and

NATIONAL ENVIRONMENTAL RESEARCH CENTER - LAS VEGAS, NEVADA

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REPORT

ON

BADIN LAKE

MONTGOMERY AND STANLY COUNTIES

NORTH CAROLINA

EPA REGION IV

WORKING PAPER No. 377

WITH THE COOPERATION OF THE

NORTH CAROLINA DEPARTMENT OF NATURAL AND ECONOMIC RESOURCES

AND THE

NORTH CAROLINA NATIONAL GUARD

JUNE, 1975

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the North Carolina Department of Natural and Economic Resources for professional involvement and to the North Carolina National Guard for conducting the tributary sampling phase of the Survey.

Lewis R. Martin, Director of the Division of Environmental Management; Darwin L. Coburn, Chief of the Water Quality Section; and Julian R. Taylor, Supervisor of the Monitoring Program Unit; provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

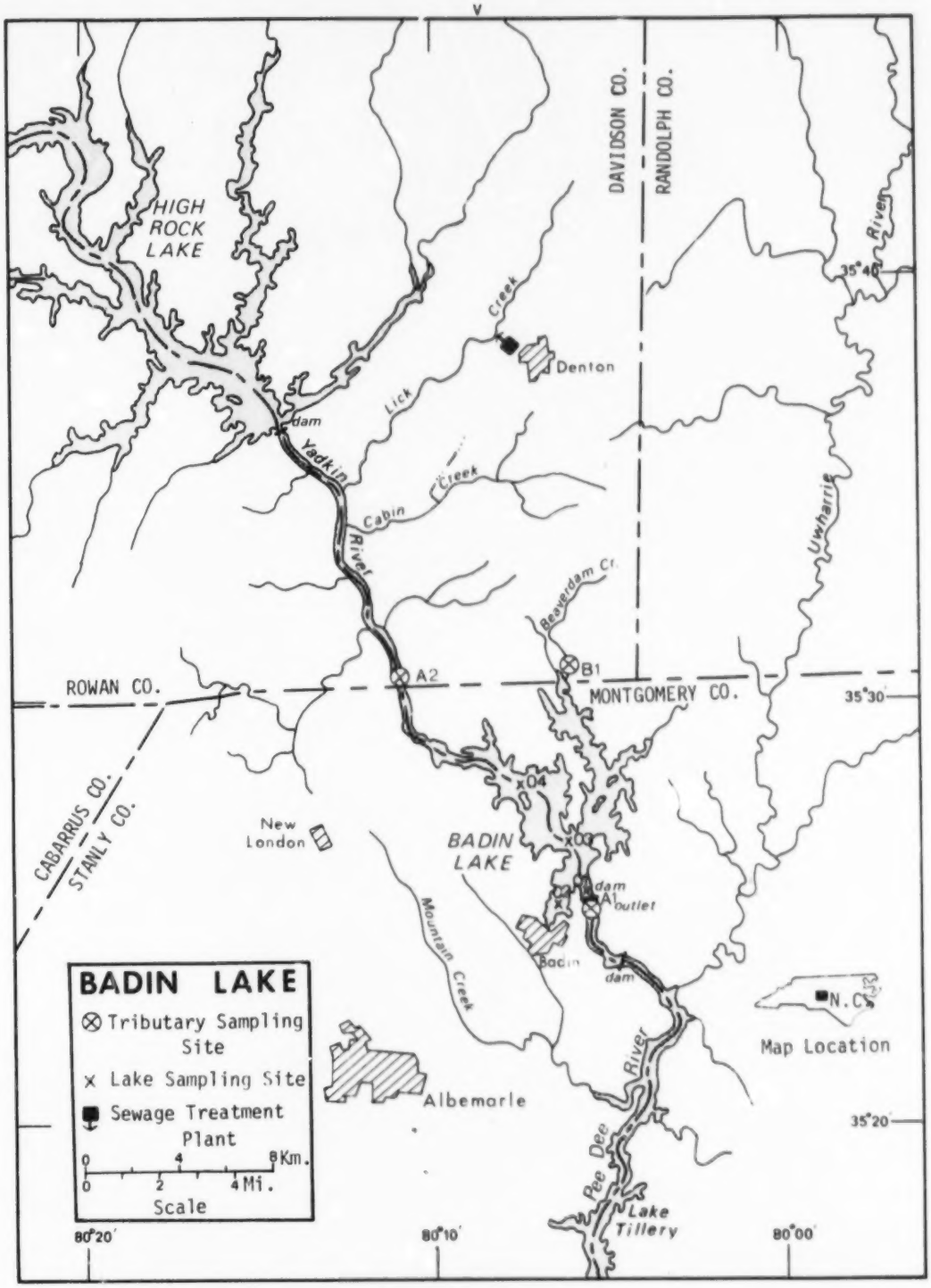
Major General William M. Buck, formerly Adjutant General of North Carolina, and Project Officer Colonel Arthur J. Bouchard, who directed the volunteer efforts of the North Carolina National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF NORTH CAROLINA

LAKE NAME	COUNTY
Badin	Montgomery, Stanly
Blewett Falls	Anson, Richmond
Chatuge	Clay, NC; Towns, GA
Fontana	Graham, Swain
Hickory	Alexander, Caldwell, Catawba
High Rock	Davidson, Rowan
Hiwassee	Cherokee
James	Burke, McDowell
John H. Kerr (Nut Bush Creek)	Granville, Vance, Warren, NC; Halifax, Mecklenburg, VA
Junaluska	Haywood
Lookout Shoals	Alexander, Catawba, Iredell
Mountain Island	Gaston, Mecklenburg
Norman	Catawba, Iredell, Lincoln, Mecklenburg
Rhodhiss	Burke, Caldwell
Santeetlah	Graham
Tillery	Montgomery, Stanly
Waccamaw	Columbus
Waterville	Haywood
Wylie	Gaston, Mecklenburg, NC; York, SC


HIGH ROCK LAKE
DAVIDSON CO.
RANDOLPH CO.
Uwharrie River
35°40'
Denton
Lick Creek
dam
Yadkin River
Cabin Creek
Reservdam Cr.
A2
B1
ROWAN CO.
MONTGOMERY CO.
35°30'
CABARRUS CO.
STANLY CO.
New London
BADIN LAKE
dam
A1
outlet
Mountain Creek
Badin
dam
N.C.
Map Location
Albemarle
Pee Dee River
35°20'
Lake Tillery
80°20'
80°10'
80°00'
BADIN LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Plant
0 4 8 Km.
0 2 4 Mi.
Scale

BADIN LAKE

STORET NO. 3701

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Badin Lake is eutrophic. However, because of the short hydraulic retention time of 28 days, the lake more closely resembles a slow-flowing river, and the term "over-enriched" may be a more appropriate description of the condition of this water body.

Badin Lake ranked fifteenth in overall trophic quality when the 16 North Carolina lakes sampled in 1973 were compared using a combination of six parameters*. Ten of the lakes had less median total phosphorus, 11 had less median dissolved phosphorus, 11 had less mean chlorophyll a, and 11 had greater mean Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred at all sampling stations in July and at stations 1 and 3 in September.

Survey limnologists noted extensive growths of emergent aquatic vegetation along the shoreline near sampling stations 2, 3, and 4; and a 45- to 55-fold increase in phytoplankton numbers occurred in July and September, and blue-green genera were dominant (see page 7).

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* See Appendix A.

B. Rate-Limiting Nutrient:

The algal assay results indicate Badin Lake was phosphorus limited at the time the sample was taken (03/24/73). The lake data indicate phosphorus limitation at all sampling stations and times; i.e., the mean inorganic nitrogen to orthophosphorus ratios were 26 to 1 or greater.

C. Nutrient Controllability:

1. Point sources--It is estimated that the community of Denton contributed only 0.3% of the total phosphorus load to Badin Lake during the sampling year.

The present phosphorus loading rate of 16.66 $g/m^2/yr$ is nearly seven times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic rate (see page 14); and, while Vollenweider's model may not be applicable to water bodies with short hydraulic retention times, the existing trophic condition of Badin Lake is evidence of excessive nutrient loads.

Control of phosphorus only at the Denton wastewater treatment plant probably would have little effect on Badin Lake. However, a high degree of phosphorus control at the point sources impacting upstream High Rock Lake* (see map, page v) should result in a significant improvement in the trophic condition of Badin Lake, since the primary productivity of the latter is phosphorus-limited.

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* Working Paper No. 381.

Considering only the phosphorus contributions of the point sources impacting High Rock Lake within the 40-kilometer limit of the Survey* and the retention in that lake during the sampling year (54%), it is calculated that 137,000 kg of the upstream point-source phosphorus load also impacted Badin Lake; i.e., 46% of the 298,000 kg point-source load impacting High Rock Lake.

2. Non-point sources--The Yadkin River contributed the largest phosphorus load of the sampled tributaries. However, on the basis of Survey data and other studies (Anonymous, 1973), much of this load can be attributed to the point sources impacting High Rock Lake as discussed above.

* See Working Paper No. 175, "...Survey Methods, 1973-1976".

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III. LAKE WATER QUALITY SUMMARY

Badin Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from four stations on the lake and from a number of depths at each station (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the four stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 50.6 meters at station 1, 16.5 meters at station 2, 35.7 meters at station 3, and 18.6 meters at station 4.

The lake sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR BADIN LAKE
STORET CODE 3701

PARAMETER	1ST SAMPLING (3/23/73) 4 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (7/11/73) 4 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (9/19/73) 4 SITES RANGE	MEAN	MEDIAN
TEMP (C)	6.8 - 14.3	12.2	12.7	6.8 - 29.8	22.9	25.9	7.2 - 26.4	22.3	25.9
DISS OXY (MG/L)	7.5 - 9.6	9.0	9.2	0.1 - 8.0	2.2	1.4	0.1 - 6.4	3.1	4.0
CNDCTVY (MCROMO)	50. - 70.	62.	62.	63. - 90.	72.	70.	50. - 75.	67.	68.
PH (STAND UNITS)	7.1 - 7.6	7.4	7.4	6.4 - 9.4	7.0	6.6	6.2 - 6.9	6.5	6.5
TOT ALK (MG/L)	10. - 22.	13.	12.	19. - 35.	24.	24.	19. - 44.	24.	21.
TOT P (MG/L)	0.077 - 0.168	0.110	0.095	0.025 - 0.064	0.038	0.040	0.013 - 0.043	0.023	0.024
ORTHO P (MG/L)	0.020 - 0.038	0.024	0.023	0.002 - 0.021	0.010	0.011	0.006 - 0.018	0.010	0.009
NO2+NO3 (MG/L)	0.470 - 0.640	0.544	0.545	0.080 - 0.700	0.397	0.420	0.030 - 0.570	0.206	0.200
AMMONIA (MG/L)	0.150 - 0.240	0.190	0.195	0.070 - 0.410	0.158	0.150	0.020 - 0.880	0.189	0.095
KJEL N (MG/L)	0.200 - 0.800	0.403	0.400	0.200 - 0.800	0.445	0.500	0.200 - 2.400	0.611	0.500
INORG N (MG/L)	0.670 - 0.800	0.734	0.735	0.150 - 0.850	0.554	0.650	0.210 - 0.920	0.395	0.290
TOTAL N (MG/L)	0.670 - 1.370	0.947	0.940	0.430 - 1.260	0.841	0.870	0.400 - 2.670	0.817	0.725
CHLRPYL A (UG/L)	3.2 - 5.5	4.5	4.6	4.5 - 7.7	6.1	6.1	9.2 - 11.8	10.4	10.3
SECCHI (METERS)	0.3 - 0.3	0.3	0.3	0.8 - 1.2	1.0	1.0	0.9 - 1.5	1.3	1.4

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B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal units per ml
03/23-24/73	1. *Cryptomonas sp.*	97
	2. *Melosira sp.*	58
	3. *Trachelomonas sp.*	48
	4. *Asterionella sp.*	48
	5. Flagellates	29
	Other genera	98
	Total	378
07/11/73	1. *Raphidiopsis sp.*	21,134
	2. *Synedra sp.*	2,138
	3. Coccoid cells	576
	4. *Microcystis sp.*	411
	5. *Scenedesmus sp.*	247
	Other genera	575
	Total	25,081
09/19/73	1. *Raphidiopsis sp.*	15,705
	2. *Oscillatoria sp.*	897
	3. *Scenedesmus sp.*	192
	4. *Melosira sp.*	124
	5. *Synedra sp.*	32
	Other genera	36
	Total	16,986

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
03/23-24/73	01	5.5
	02	3.2
	03	5.2
	04	4.1
07/11/73	01	-
	02	-
	03	7.7
	04	4.5
09/19/73	01	9.9
	02	10.8
	03	11.8
	04	9.2

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.028	0.424	6.3
0.050 P	0.078	0.424	14.4
0.050 P + 1.0 N	0.078	1.424	24.4
1.0 N	0.028	1.424	6.8

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Badin Lake was high at the time the sample was collected (03/24/73). The addition of phosphorus alone resulted in an increase in yield which indicates phosphorus limitation

(note that the addition of only nitrogen did not significantly increase the yield over that of the control).

The lake data substantiate that Badin Lake was phosphorus limited. At all sampling stations and times, the mean inorganic nitrogen to orthophosphorus ratios were 26 to 1 or greater.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the North Carolina National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of January and February when two samples were collected. Sampling was begun in March, 1973, and was completed in March, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the North Carolina District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in $kg/km^2/year$, at station B-1 and multiplying the means by the ZZ area in km^2.

The operator of the Denton wastewater treatment plant did not participate in the Survey, and nutrient loads were estimated at 1.134 kg P and 3.401 kg N/capita/year.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)**	Receiving Water
Denton	1,017	trickling filter	384.9	Lick Creek

2. Known industrial - None

* Anonymous, 1971.
** Estimated at 0.3785 m^3/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Yadkin River	399,530	99.2
Beaverdam Creek	255	0.1
b. Minor tributaries & immediate drainage (non-point load) -	1,245	0.3
c. Known municipal STP's -		
Denton	1,155	0.3
d. Septic tanks* -	55	<0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	425	0.1
Total	402,665	100.0

2. Outputs -

Lake outlet - Yadkin River 316,515

3. Net annual P accumulation - 86,150 kg.

* Estimate based on 201 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/ yr	% of total
a. Tributaries (non-point load) -		
Yadkin River	5,179,290	98.7
Beaverdam Creek	6,170	0.1
b. Minor tributaries & immediate drainage (non-point load) -	30,250	0.6
c. Known municipal STP's -		
Denton	3,460	0.1
d. Septic tanks* -	2,140	<0.1
e. Known industrial - None	-	-
f. Direct precipitation* -	26,095	0.5
Total	5,247,405	100.0

2. Outputs -

Lake outlet - Yadkin River 5,275,525

3. Net annual N loss - 28,120 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg $P/km^2/yr$	kg $N/km^2/yr$
Yadkin River	37	486
Beaverdam Creek	11	267

* Estimate based on 201 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" rate is the rate at which the receiving water would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	16.66	3.56	217.1	loss*

Vollenweider loading rates for phosphorus ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Badin Lake:

"Dangerous" (eutrophic rate)	2.50
"Permissible" (oligotrophic rate)	1.25

* There was an apparent loss of nitrogen during the sampling year. This may have been due to nitrogen fixation in the lake, solubilization of previously sedimented nitrogen, recharge with nitrogen-rich ground water, or unknown and unsampled point sources discharging directly to the lake. Whatever the cause, a similar nitrogen loss has occurred at Shagawa Lake, Minnesota, which has been intensively studied by EPA's National Eutrophication and Lake Restoration Branch (Malueg et al., 1975).

V. LITERATURE REVIEWED

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3719	LAKE WACCAMAW	534
2	3716	SANTEELAH LAKE	446
3	3711	MOUNTAIN ISLAND LAKE	419
4	3707	HIWASSEE LAKE	414
5	3704	FONTANA LAKE	392
6	3713	LAKE NORMAN	346
7	3708	LAKE JAMES	334
8	3710	LOOKOUT SHOALS	327
9	3715	RHODHISS LAKE	296
10	3705	LAKE HICKORY	283
11	3717	LAKE TILLERY	246
12	3709	LAKE JUNALUSKA	220
13	3702	BLEWETT FALLS LAKE	200
14	3718	WATERVILLE RESERVOIR	140
15	3701	BADIN LAKE	124
16	3706	HIGH ROCK LAKE	76

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3701	BADIN LAKE	33 (5)	7 (1)	27 (4)	27 (4)	3 (0)	27 (4)	124
3702	BLEWETT FALLS LAKE	7 (1)	13 (2)	7 (1)	73 (11)	93 (14)	7 (1)	200
3704	FONTANA LAKE	100 (15)	33 (5)	93 (14)	100 (15)	3 (0)	63 (9)	392
3705	LAKE HICKORY	27 (4)	60 (9)	53 (8)	13 (2)	80 (12)	50 (7)	283
3706	HIGH ROCK LAKE	13 (2)	20 (3)	0 (0)	0 (0)	23 (2)	20 (3)	76
3707	HIWASSEE LAKE	87 (13)	80 (12)	87 (13)	47 (7)	50 (7)	63 (9)	414
3708	LAKE JAMES	60 (9)	87 (13)	80 (12)	7 (1)	23 (2)	77 (11)	334
3709	LAKE JUNALUSKA	47 (7)	27 (4)	43 (6)	20 (3)	50 (7)	33 (5)	220
3710	LOOKOUT SHOALS	53 (8)	47 (7)	60 (9)	67 (10)	60 (9)	40 (6)	327
3711	MOUNTAIN ISLAND LAKE	73 (11)	73 (11)	43 (6)	53 (8)	87 (13)	90 (13)	419
3713	LAKE NORMAN	67 (10)	53 (8)	73 (11)	40 (6)	23 (2)	90 (13)	346
3715	RHODHISS LAKE	20 (3)	67 (10)	33 (5)	93 (14)	70 (10)	13 (2)	296
3716	SANTEELAH LAKE	93 (14)	93 (14)	100 (15)	60 (9)	23 (2)	77 (11)	446
3717	LAKE TILLERY	40 (6)	40 (6)	13 (2)	33 (5)	70 (10)	50 (7)	246
3718	WATERVILLE RESERVOIR	0 (0)	0 (0)	20 (3)	80 (12)	40 (6)	0 (0)	140
3719	LAKE WACCAMAW	80 (12)	100 (15)	67 (10)	87 (13)	100 (15)	100 (15)	534

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P
3701	BADIN LAKE	0.042	0.680	466.750	7.190	14.900	0.012
3702	BLEWETT FALLS LAKE	0.090	0.655	476.889	4.167	10.800	0.034
3704	FONTANA LAKE	0.011	0.550	392.650	3.438	14.900	0.007
3705	LAKE HICKORY	0.047	0.320	461.000	7.275	13.400	0.008
3706	HIGH ROCK LAKE	0.090	0.580	477.454	14.283	14.800	0.017
3707	HIWASSEE LAKE	0.015	0.240	420.555	5.678	14.200	0.007
3708	LAKE JAMES	0.020	0.160	428.866	7.660	14.800	0.006
3709	LAKE JUNALUSKA	0.031	0.560	462.000	7.233	14.200	0.009
3710	LOOKOUT SHOALS	0.026	0.370	459.167	4.200	13.800	0.008
3711	MOUNTAIN ISLAND LAKE	0.018	0.270	462.000	5.580	12.800	0.005
3713	LAKE NORMAN	0.019	0.330	446.667	5.807	14.800	0.005
3715	RHODHISS LAKE	0.061	0.305	462.111	3.578	13.600	0.019
3716	SANTEELAH LAKE	0.011	0.160	366.400	5.360	14.800	0.006
3717	LAKE TILLERY	0.040	0.470	468.600	6.827	13.600	0.008
3718	WATERVILLE RESERVOIR	0.103	0.860	468.333	3.817	14.400	0.041
3719	LAKE WACCAMAW	0.018	0.120	455.667	3.583	9.800	0.004

APPENDIX B

CONVERSIONS FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR NORTH CAROLINA 10/21/75

LAKE CODE 3701 BADIN LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ MI) 4177.00

TRIBUTARY	SUB-DRAINAGE AREA(SQ MI)	NORMALIZED FLOWS(CFS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3701A1	4177.00	6070.00	6840.00	7230.00	6620.00	4960.00	4060.00	3710.00	4100.00	3970.00	4000.00	3870.00	4630.00	4994.03
3701A2	4115.00	5990.00	6720.00	7100.00	6530.00	4920.00	4030.00	3680.00	4070.00	3930.00	3970.00	3840.00	4580.00	4936.08
3701B1	8.90	12.00	18.00	17.00	12.00	6.20	4.20	4.90	5.20	4.90	4.10	4.60	7.80	8.35
3701ZZ	53.10	75.00	100.00	115.00	73.00	37.00	25.00	29.00	31.00	29.00	24.00	28.00	46.00	50.73

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 4177.00 TOTAL FLOW IN = 60072.89
SUM OF SUB-DRAINAGE AREAS = 4177.00 TOTAL FLOW OUT = 60060.00

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3701A1	3	73	10900.00	25	7940.00				
	4	73	11300.00	29	28700.00				
	5	73	8400.00						
	6	73	6700.00	3	8020.00				
	7	73	5200.00	8	10.00				
	8	73	5900.00	5	8920.00				
	9	73	3070.00	9	10.00				
	10	73	3450.00	14	10.00				
	11	73	3800.00	4	1520.00				
	12	73	6120.00	2	10.00				
	1	74	10100.00	6	8290.00	18	7580.00		
	2	74	8890.00	3	9220.00	14	8800.00		
	3	74	6110.00	3	7460.00				
3701A2	3	73	10800.00	25	8070.00				
	4	73	11000.00	29	28200.00				
	5	73	8350.00						
	6	73	6600.00	3	7160.00				
	7	73	5160.00	8	35.00				
	8	73	5840.00	5	9020.00				
	9	73	3060.00	9	25.00				
	10	73	3410.00	14	15.00				
	11	73	3660.00	4	1540.00				
	12	73	6240.00	2	25.00				
	1	74	10000.00	6	8470.00	18	7470.00		
	2	74	8770.00	3	7600.00	14	8420.00		
	3	74	6030.00	3	7400.00				

TRIBUTARY FLOW INFORMATION FOR NORTH CAROLINA 10/21/75

LAKE CODE 3701 BADIN LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
370161	3	73	23.00	25	12.00				
	4	73	38.00	29	12.00				
	5	73	8.50						
	6	73	9.00	3	4.90				
	7	73	5.80	8	4.80				
	8	73	4.30	5	7.90				
	9	73	1.80	9	1.10				
	10	73	0.70	14	0.70				
	11	73	1.20	4	0.90				
	12	73	4.90	2	1.60				
	1	74	15.00	6	6.90	18	4.00		
	2	74	17.00	3	54.00	14	8.00		
	3	74	9.60	3	7.00				
370122	3	73	135.00						
	4	73	180.00						
	5	73	50.00						
	6	73	55.00						
	7	73	35.00						
	8	73	25.00						
	9	73	11.00						
	10	73	5.00						
	11	73	10.00						
	12	73	29.00						
	1	74	87.00						
	2	74	105.00						
	3	74	57.00						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 73/10/20

370101
35 25 20.0 080 05 35.0
MADIN LAKE
37167 NORTH CAROLINA

11EPALES
3

2111202
0170 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/03/23	13 50	0000	14.1		10	70	7.40	14	0.220	0.300	0.520	0.026
	13 50	0005	14.3	9.6		65	7.40	13	0.200	0.200	0.480	0.026
	13 50	0010	14.1	9.6		65	7.40	12	0.210	0.200	0.490	0.025
	13 50	0020	14.0	9.6		65	7.40	10	0.200	0.200	0.480	0.025
	13 50	0030	13.8	9.6		65	7.40	10	0.200	0.200	0.470	0.024
	13 50	0045	13.7	9.5		65	7.20	19	0.240	0.500	0.470	0.033
	13 50	0060	13.7	9.3		65	7.20	22	0.210	0.400	0.470	0.026
	13 50	0080	9.8	9.0		62	7.10	20	0.180	0.300	0.560	0.026
	13 50	0100	8.0	8.8		62	7.20	19	0.150	0.200	0.580	0.025
	13 50	0125	7.2	7.6		62	7.20	21	0.180	0.300	0.560	0.026
	13 50	0145	7.1	7.3		60	7.20	12	0.160	0.300	0.540	0.038
	13 50	0166	7.1	7.8		55	7.30	20	0.230	0.400	0.540	0.030
73/07/11	09 45	0000	28.9		48	75	9.00	21	0.090	0.800	0.100	0.005
	09 45	0005	28.9	4.0		69	8.70	19	0.070	0.600	0.080	0.007
	09 45	0015	26.3	2.2		69	6.60	20	0.150	0.500	0.420	0.013
	09 45	0030	25.9	1.8		70	6.50	21	0.170	0.400	0.480	0.011
	09 45	0050	25.4	1.0		70	6.50	20	0.170	0.500	0.490	0.012
	09 45	0075	19.0	0.6		70	6.50	23	0.120	0.400	0.540	0.021
	09 45	0100	10.7	0.6		70	6.40	21	0.070	0.400	0.700	0.015
	09 45	0125	7.2	0.3		78	6.40	24	0.160	0.500	0.690	0.015
	09 45	0155	6.8	0.2		83	6.50	28	0.290	0.700	0.560	0.014
73/09/14	14 05	0000	26.4		56	66	6.90	21	0.050	0.500	0.220	0.007
	14 05	0005	26.1	4.4		68	6.60	21	0.060	0.500	0.230	0.007
	14 05	0015	26.0	4.2		67	6.50	21	0.060	0.300	0.230	0.011
	14 05	0040	25.6	3.8		68	6.50	22	0.060	0.200K	0.230	0.009
	14 05	0070	25.4	2.0		70	6.40	25	0.160	0.200K	0.200	0.007
	14 05	0080	17.4	0.3		60	6.30	22	0.080	0.200K	0.440	0.009
	14 05	0105	10.3	0.2		50	6.20	21	0.110	0.200K	0.570	0.010
	14 05	0130	7.3	0.3		54	6.60	36	0.700	0.800	0.130	0.007
	14 05	0155	7.2	0.1		72	6.60	44	0.880	1.200	0.040	0.010

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/20

370101
35 25 20.0 080 05 35.0
BADIN LAKE
37167 NORTH CAROLINA

11EPALES 2111202
3 0170 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/03/23	13 50	0000	0.047	5.5
	13 50	0006	0.042	
	13 50	0014	0.041	
	13 50	0022	0.049	
	13 50	0030	0.047	
	13 50	0045	0.047	
	13 50	0065	0.045	
	13 50	0080	0.078	
	13 50	0100	0.087	
	13 50	0125	0.088	
	13 50	0145	0.090	
	13 50	0166	0.102	
73/07/11	09 45	0000	0.025	
	09 45	0005	0.028	
	09 45	0015	0.030	
	09 45	0030	0.040	
	09 45	0050	0.041	
	09 45	0075	0.031	
	09 45	0100	0.042	
	09 45	0125	0.042	
	09 45	0156	0.037	
73/09/19	14 05	0000	0.017	9.9
	14 05	0005	0.015	
	14 05	0015	0.015	
	14 05	0040	0.015	
	14 05	0070	0.017	
	14 05	0080	0.020	
	14 05	0105	0.024	
	14 05	0130	0.024	
	14 05	0155	0.025	

37

STORET RETRIEVAL DATE [illegible]

370102
35 24 57.0 080 06 33.0
BADIN LAKE
37167 NORTH CAROLINA

11EPALES 2111202
3 0055 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/03/24	09 40	0000	13.3		10	65	7.30	11	0.160	0.600	0.520	0.027
	09 40	0006	13.2	9.5		60	7.40	11	0.170	0.400	0.530	0.026
	09 40	0012	13.2	9.4		60	7.40	12	0.170	0.400	0.520	0.025
	09 40	0018	13.1	9.3		60	7.30	12	0.160	0.400	0.530	0.028
	09 40	0025	12.9	9.2		60	7.30	12	0.170	0.400	0.530	0.021
	09 40	0035	12.7	9.1		60	7.40	10	0.190	0.500	0.550	0.022
	09 40	0051	12.2	8.8		60	7.30	10K	0.200	0.400	0.560	0.020
73/07/11	11 00	0000	27.9		36	69	8.50	22	0.080	0.600	0.130	0.004
	11 00	0005	27.9	7.0		69	7.40	21	0.100	0.700	0.170	0.007
	11 00	0015	27.1	6.2		69	6.90	21	0.070	0.500	0.220	0.004
	11 00	0030	26.3	2.0		70	6.60	26	0.150	0.500	0.410	0.006
	11 00	0045	25.9	1.0		70	6.60	27	0.190	0.500	0.410	0.006
73/09/19	13 40	0000	26.2		60	65	6.70	20	0.030	0.600	0.280	0.006
	13 40	0005	26.2	9.4		64	6.60	20	0.030	0.400	0.280	0.007
	13 40	0015	26.6	9.5		64	6.50	19	0.020	2.400	0.270	0.007
	13 40	0030	26.1	9.4		64	6.40	20	0.030	0.400	0.270	0.011
	13 40	0054	26.0	9.0		65	6.30	20	0.020	0.400	0.260	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/03/24	09 40	0000	0.044	1.2
	09 40	0006	.065	
	09 40	0012	0.080	
	09 40	0018	1.077	
	09 40	0025	.077	
	09 40	0035	.131	
	09 40	0051	.184	
73/07/11	11 00	0000	0.044	
	11 00	0005	.035	
	11 00	0015	.032	
	11 00	0030	.026	
	11 00	0045	.037	
73/09/19	13 40	0000	.014	1.0
	13 40	0005	.014	
	13 40	0015	.014	
	13 40	0030	.014	
	13 40	0054	.014	

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/20

370103
35 26 27.0 080 06 01.0
HADIN LAKE
37167 NORTH CAROLINA

11EPALES 2111202
3 0119 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/03/24	10 30	0000	13.1		10	70	7.50	14	0.170	0.400	0.540	0.023
	10 30	0006	13.0	9.6		60	7.50	14	0.160	0.400	0.540	0.023
	10 30	0014	12.9	9.3		68	7.50	16	0.160	0.400	0.530	0.026
	10 30	0022	12.8	9.4		68	7.40	14	0.170	0.400	0.540	0.022
	10 30	0030	12.9	9.4		68	7.40	13	0.200	0.400	0.560	0.025
	10 30	0040	12.7	9.2		65	7.40	10	0.200	0.500	0.570	0.021
	10 30	0055	12.3	8.8		60	7.40	10K	0.210	0.500	0.570	0.023
	10 30	0075	11.8	8.6		58	7.30	10K	0.200	0.500	0.580	0.020
	10 30	0090	7.5	8.6		67	7.20	12	0.170	0.300	0.600	0.023
	10 30	0115	6.8	7.9		64	7.20	10	0.150	0.300	0.640	0.022
73/07/11	14 00	0000	29.8		40	72	9.40	23	0.080	0.500	0.080	0.002
	14 00	0009	28.4	8.0		63	8.60	24	0.090	0.300	0.130	0.004
	14 00	0015	26.5	2.6		70	6.60	24	0.190	0.200K	0.410	0.007
	14 00	0030	25.8	2.0		70	6.50	23	0.170	0.200K	0.480	0.012
	14 00	0045	25.3	1.0		70	6.40	24	0.100	0.200K	0.560	0.012
	14 00	0060	23.6	0.3		70	6.40	23	0.120	0.200K	0.560	0.01[illegible]
	14 00	0080	16.4	0.2		72	6.40	27	0.150	0.200K	0.550	0.012
	14 00	0100	10.7	0.2		80	6.50	29	0.200	0.300	0.560	0.012
	14 00	0117	8.0	0.1		90	6.60	35	0.410	0.500	0.410	0.013
73/09/19	13 10	0000	26.2		52	69	6.80	21	0.080	0.600	0.200	0.016
	13 10	0005	25.9	3.2		68	6.40	20	0.080	0.400	0.230	0.010
	13 10	0015	25.9	4.6		68	6.50	20	0.070	0.400	0.170	0.009
	13 10	0035	25.9	5.2		69	6.50	20	0.070	0.600	0.140	0.012
	13 10	0055	25.9	4.0		69	6.40	20	0.110	0.500	0.180	0.018
	13 10	0075	24.5	1.2		68	6.40	21	0.200	0.600	0.200	0.010
	13 10	0080	18.8	0.2		72	6.50	33	0.510	0.900	0.030	0.011
	13 10	0095	11.8	0.2		59	6.50	27	0.370	0.800	0.280	0.012
	13 10	0115	8.6	0.3		70	6.50	40	0.780	1.200	0.030	0.007

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/20

370103
35 26 27.0 080 06 01.0
BADIN LAKE
37167 NORTH CAROLINA

11EPALES 2111202
3 0119 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/03/24	10 30	0000	0.090	5.2
	10 30	0006	0.084	
	10 30	0014	0.088	
	10 30	0022	0.088	
	10 30	0030	0.104	
	10 30	0040	0.139	
	10 30	0055	0.142	
	10 30	0075	0.166	
	10 30	0090	0.086	
	10 30	0115	0.096	
73/07/11	14 00	0000	0.026	7.7
	14 00	0009	0.040	
	14 00	0015	0.044	
	14 00	0030	0.048	
	14 00	0045	0.033	
	14 00	0060	0.031	
	14 00	0080	0.032	
	14 00	0100	0.042	
	14 00	0117	0.040	
73/09/19	13 10	0000	0.027	11.8
	13 10	0005	0.021	
	13 10	0015	0.026	
	13 10	0035	0.028	
	13 10	0055	0.028	
	13 10	0075	0.021	
	13 10	0080	0.026	
	13 10	0095	0.027	
	13 10	0115	0.030	

STORET RETRIEVAL DATE 75/10/20

370104
35 27 58.0 080 07 28.0
BADIN LAKE
37 NORTH CAROLINA

11EPALES 2111202
3 0060 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/03/24	13 15	0000	13.6		10	70	7.50	11	0.210	0.800	0.570	0.022
	13 15	0006	12.7	9.3		58	7.60	10	0.200	0.500	0.580	0.020
	13 15	0012	12.6	9.2		58	7.50	10	0.220	0.400	0.580	0.022
	13 15	0020	12.6	9.2		55	7.50	11	0.180	0.500	0.550	0.021
	13 15	0030	12.5	9.0		55	7.50	11	0.200	0.500	0.580	0.021
	13 15	0045	12.4	9.0		50K	7.50	11	0.180	0.600	0.560	0.020
	13 15	0056	11.9	8.8		55	7.40	10	0.210	0.500	0.590	0.021
73/07/11	15 00	0000	29.3		30	70	8.30	25	0.110	0.500	0.200	0.005
	15 00	0006	27.2	3.8		70	6.80	25	0.150	0.400	0.330	0.004
	15 00	0015	26.2	2.2		70	6.70	24	0.200	0.300	0.440	0.008
	15 00	0030	25.9	2.0		70	6.60	23	0.210	0.400	0.470	0.012
	15 00	0045	25.4	1.4		70	6.50	26	0.150	0.400	0.540	0.016
	15 00	0061	23.1	0.2		78	6.60	29	0.360	0.700	0.380	0.009
73/09/19	12 50	0000	26.2		37	72	6.80	24	0.150	0.700	0.140	0.016
	12 50	0005	26.0	4.6		73	6.60	24	0.140	0.500	0.130	0.009
	12 50	0015	25.9	4.6		74	6.50	24	0.140	0.500	0.130	0.008
	12 50	0035	25.8	6.2		74	6.40	24	0.140	0.500	0.140	0.010
	12 50	0060	25.6	4.0		75	6.60	24	0.150	0.600	0.130	0.010

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/20

370104
35 27 58.0 080 07 28.0
BADIN LAKE
37 NORTH CAROLINA

11EPALES 2111202
3 0060 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/03/24	13 15	0000	0.139	4.1
	13 15	0006	0.145	
	13 15	0012	0.143	
	13 15	0020	0.143	
	13 15	0030	0.150	
	13 15	0045	0.149	
	13 15	0056	0.168	
73/07/11	15 00	0000	0.064	4.5
	15 00	0006	0.040	
	15 00	0015	0.046	
	15 00	0030	0.053	
	15 00	0045	0.044	
	15 00	0061	0.034	
73/09/19	12 50	0000	0.040	9.2
	12 50	0005	0.030	
	12 50	0015	0.031	
	12 50	0035	0.029	
	12 50	0060	0.043	

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/10/20

3701A1 LS3701A1
35 25 00.0 080 05 30.0
YADKIN RIVER
37009 15 ALBEMARLE
O/BADIN LAKE
BADEN DAM 1.5 MI NE OF TOWN OF BADEN
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/03/25	10	25	0.430	0.640	0.138	0.038	0.120
73/04/29	07	02	0.450	0.440	0.068	0.029	0.065
73/06/03	08	20	0.370	0.460	0.100	0.016	0.065
73/07/08	08	30	0.530	0.320	0.054	0.011	0.035
73/08/05	08	30	0.240	0.760	0.082	0.014	0.040
73/09/09	08	31	0.490	1.150	0.100	0.016	0.030
73/10/14	08	50	0.270	1.450	0.210	0.021	0.050
73/11/04	08	35	0.280	0.500	0.126	0.013	0.035
74/01/06	08	45	0.540	0.900	0.168	0.026	0.085
74/01/18	11	00	0.620	1.100	0.140	0.045	0.100
74/02/03	09	30	0.540	0.300	0.076	0.032	0.095
74/02/14	10	40	0.504	0.400	0.070	0.035	0.120
74/03/03	08	30	0.460	1.000	0.085	0.030	0.075

STORET RETRIEVAL DATE 75/10/20

3701A2 LS3701A2
35 30 00.0 080 11 00.0
YADKIN RIVER
37 15 DENTON
I/HADEN LAKE
STOKES FERRY BRDG ON ST HWYS 8 AND 49
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/03/25	11 55		0.390	0.630	0.120	0.052	0.125
73/04/29	10 10		0.252	0.560	0.093	0.018	0.070
73/06/03	09 40		0.480	0.660	0.066	0.027	0.125
73/07/08	06 10		0.198	0.520	0.027	0.005K	0.052
73/08/05	08 42		0.110	0.680	0.140	0.010	0.060
73/09/09	08 55		0.014	1.700	0.044	0.006	0.040
73/10/14	08 45		0.250	1.550	0.390	0.012	0.060
73/11/04	08 40		0.220	1.000	0.150	0.019	0.065
74/01/05	09 00		0.520	0.600	0.132	0.032	0.115
74/01/18	09 00		0.560	0.600	0.132	0.030	0.105
74/02/03	09 03		0.480	0.500	0.112	0.038	0.120
74/02/14	10 00		0.460	0.700	0.090	0.040	0.135
74/03/03	09 15		0.440	0.900	0.085	0.035	0.100

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/20

370181 LS370181
35 31 00.0 080 06 00.0
BEAVERDAM CREEK
37 15 DENTON
T/BADIN LAKE
XING DAVIDSON CO RD 1156 3.5 NW BLAINE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/03/25	11	20	0.231	0.460	0.024	0.010	0.040
73/04/29	09	03	0.150	0.520	0.040	0.007	0.040
73/06/03	10	00	0.083	0.420	0.027	0.005K	0.035
73/07/08	06	25	0.014	0.460	0.012	0.005K	0.025
73/08/05	09	25	0.010K	0.690	0.012		0.035
73/09/09	09	20	0.010K	0.785	0.013	0.006	0.030
73/10/14	09	00	0.084	1.250	0.069	0.008	0.040
73/11/04	09	15	0.210	0.950	0.048	0.010	0.035
73/12/02	09	20	0.220	0.600	0.032	0.005K	0.035
74/01/06	09	30	0.460	0.500	0.036	0.005K	0.020
74/01/18	09	15	0.128	0.400	0.044	0.008	0.015
74/02/03	09	40	0.200	1.200	0.064	0.016	0.050
74/02/14	10	25	0.252	1.000	0.100	0.010	0.060
74/03/03	10	05	0.040	0.300	0.025	0.005K	0.017

K VALUE KNOWN TO BE
LESS THAN INDICATED